# Parallel

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***Abstract* – In this paper we present Parallel, a videogame with a powerful story of mystery, suspense and puzzle-solving. Parallel provides an interactive storyline where the actions players take throughout the game will define the course of the story and alter events. The environment created in the game is unique and it was improved from testing with several subjects on a prototype of the tutorial. Parallel's main potential is the sense of immersion it can provide with its obscure environment, dynamic dialogs using an artificial intelligent agent and its interactive storyline.**

***Keywords* –** *Computer Games, Multiverse, Interactive Storyline, Puzzle, Artificial Intelligence.*

## I. Introduction

Videogames are one of the main forms of multimedia today, thousands of games are created yearly. "Video games are a multi-billion dollar industry in the United States" [1], and can be used in different contexts – entertainment, edutainment, pedagogical, serious games, etc. The videogame presented in this paper is named Parallel because it presents a story where multiple universes coexist. Essentially is the story of a scientist that wakes up in an unknown universe, and using his abilities to solve puzzles and explore the dark mysteries of that universe, finds a way to travel back to his original universe, where his home is. The puzzles are diversified and not limited to a single mechanism, they require the understanding of physics for platform puzzles, maths for logical puzzles and the use of deduction to choose the best pathway possible.

The main contribution of this paper is a videogame that can potentially be referenced as state of the art in interactive storytelling on the domain of games and entertainment.

In section II we present the methodology used for the development of the game. In section III we detail all the aspects of the development of the game. In section IV we discuss the tests made with the prototype of the tutorial and the results obtained. Finally, in section V we present the conclusions of our paper and future work.

## II. Project Basics

The aim for this game is an immersive experience that can grab its players into a powerful fictional story of science mixed with fantasy, while presenting its own perspective on interactive storylines.

Parallel went through several stages of development, however the one of the most important was the story creation, as described in [5]. By writing a full screenplay of the story of Parallel, detailing cut-scenes, dialogs, mechanics and environments, we were able to build a powerful guide for the implementation of the game itself.

Followed by conception was the implementation stage. At this stage, many decisions were made that directly affected the behavior of the game. Since the goal was to create an immersive experience, the first-person perspective was adopted in the game, hopefully making the players feel like they were the main character in the game [2].

The target audience of the game is people with gaming experience.

That being said, the reward system implemented had both short-term and long-term rewards that could provide a good and more enjoyable game [3]. Memory boosts work as short-term mechanics that the player has to pursue in order to solve puzzles and move on to the next level – floor. Mechanics of short-term vs long-term rewards can also be seen in the player's choices throughout the game. There is always two ways of solving each puzzle with the most direct (short-term) having a negative impact on the Insanity level of the character.

The design of the environment and locations had to be extremely well put together due to it being darker than regular videogames. The quality of the motion in the game considered the frame rate used, effects like motion blur were readjusted taking these factors into consideration [6] [7], as well as the tests done with several subjects.

To accomplish scheduled objectives and avoid missing the stage of testing with end-users, a prototype of the game was developed, which consisted of the tutorial presented in the beginning of the game.

After the implementation of the prototype and all the ideas for the rest of the game were defined, in the last stage of development, informal tests were made with 6 people from the target audience. These tests gave enough feedback to the developers who proceeded to implement the remainder of the defined objectives in the game. Additionally, after implementing those objectives into the game, final tests were done with 6 more test subjects.

## III. Project Development

### III.1 Conception

As mentioned in section II, before the implementation of the game, this project began with the game conception.

Parallel tells the story of John, a scientist that finds himself trapped in a mysterious and dark universe. In this universe, he is confined to two skyscrapers, which seem to never end below him, John has to discover what happened to him and where exactly he is. Eventually he manages to communicate through the multiverse with his daughter Sarah, who is being held in the regular universe by John's rival Richard, a great scientist with unknown intentions. By communicating with his daughter, John manages to find his way through the parallel universe he is trapped in, by solving platform and logic puzzles, avoiding obstacles such as black holes and falling into the void. By solving the puzzles, and his daughter's clues, he figures out the chemical equation he has been searching his whole life. This equation allows him to travel through universes, and it explains why he ended up in the parallel universe and was stuck there. The story ends with John successfully returning back to his home universe, and confronting Richard for kidnapping his daughter and trapping him in the parallel universe.

A document with the screenplay for this story was created and improved throughout the development of the game. This screenplay divided the story in 3 acts: the first act contains a tutorial and introduction to the game where John has to solve two different puzzles and has the initial interaction with Sarah; the second act fleshes out the story and is mainly the development part of it, where John has to solve two more puzzles and communicate with Sarah to move forward in the storyline; and the third act, in which the final puzzle is solved and the confrontation between the main character John and its rival Richard takes place.

The main concepts introduced in this videogame is the *Memory Mode* and the *Insanity* meter. The *Memory Mode* is a tool that John can use throughout the game to access flashbacks of his memory and see what the real world looks like in that current space of the parallel world. This tool is essential for solving puzzles, since some pathways or information are only visible in memory mode.

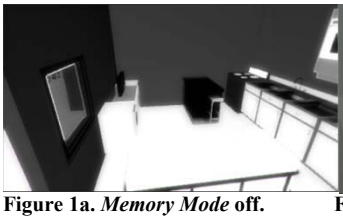

**Figure 1a. *Memory Mode* off.**

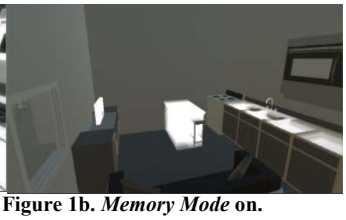

**Figure 1b. *Memory Mode* on.**

The *Insanity* meter is a meter that evolves throughout the playthrough of the game. In every puzzle John has a sane and an insane way of solving it, and every time John solves it in the insane way, his insanity meter goes up. This measure influences the dialogs of the intelligent agent and the interactive storyline (chapter C of section III.2).

**Figure 2. *Insanity* meter empty (sane) and totally filled (insane).**

The tutorial consists of an introduction to the keys needed to play and to mechanics such as the *Memory Mode*. In the tutorial, the player must use the memory mode in one situation in order to progress, and in the final event he can opt to choose the *Memory Mode* to finish the tutorial or kick down a door, the last one being the insane way of solving this event.

For testing purposes, a prototype of the tutorial for the first act of the game was implemented before the rest of the game. The final game contains the story of act 1 and act 3, act 2 remained on paper as concept to be implemented in the future.

III.2 Implementation

The game was developed using the Unity 5 Game Engine[Unity]. This engine was chosen because the authors had prior experience with Unity, it is a free software and currently one of the best engines in the market.

A. Physics

The implementation stage began by creating the look and feel of the game itself. The parallel universe had to create an unorthodox feeling (movement and gameplay mechanics) in the player to stand out. For this purpose, a series of post-render image effects (already built-in in Unity) were used to create the dark and mysterious environment. The gameplay mechanics can be described as:

a) Player Movement;
b) *Memory Mode*;
c) Object pickup;
d) Object interaction.

Player Movement is already built-in on Unity, as there are already First-Person Controllers ready to do the heavy-lifting of physics and input reactions. *Memory Mode* is the mode that changes the look of the game to a normal state (textured), and to achieve this, whenever it is activated, the post-render image effects mentioned above are turned off. Object pickup and interaction were created so the player could pick up important objects and use them when needed, for example, for restoring the *Memory Mode* the player can use a *Memory* which is a floating consumable item available throughout the map. To give some player feedback, we created an animation of a hand appearing on screen with a "pickup" motion. The hand is from a 3D Humanoid Model generated with Autodesk's Character Generator [Autodesk] which is a great way to create high quality 3D Humanoid Characters for no cost for students.

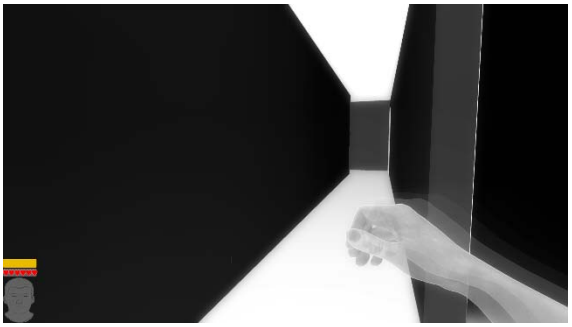

**Figure 3. Grabbing hand.**

At this stage, the game was already playable, the player could move around and interact with objects, and the next stage is the creation of the final environment in which all the story takes place.

B. Environments and Locations

The whole 3D model was developed in Autodesk Revit 2017 [Revit] based on an architectural system that was designed to accommodate a procedural generation of the skyscrapers levels. The authors took this approach to allow the conception of as many puzzles as wanted, so the game could grow on a systematic fashion. The shape of the skyscrapers is simple: two rectangular towers that give a dynamic feeling due to their voids on the surface that give birth to public space.

The general rules that allowed us to specify this system was to have at least 35% of free space (that is, only 65% of each level could be built space) while accommodating at least a sample of each house typology ranging from T1 to T3. The sum of these rules resulted in an area of 15x16 per level. A matrix was fitted to each level with 5 cells of 3m (5x3) per 8 cells of 2m (8x2). Figure 4 shows a sample level made by this system. There are two variants for each house typology that go from T1 to T3 as depicted in Figure 5.

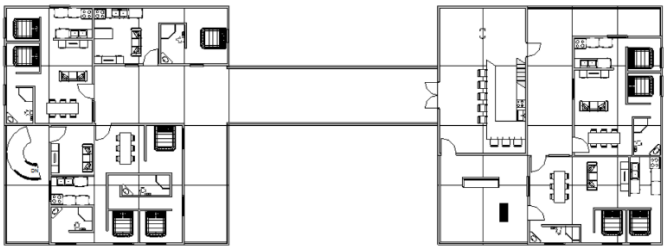

**Figure 4. Sample level.**

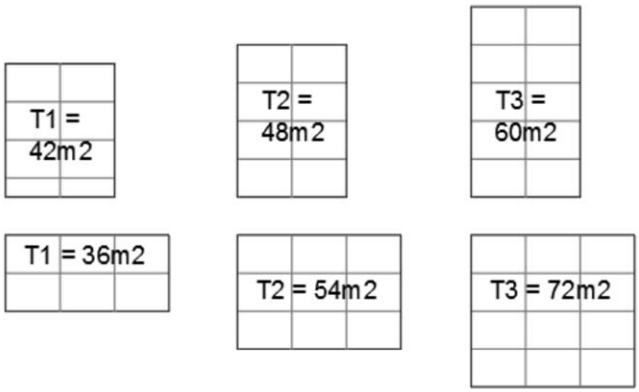


**Figure 5. House typologies superimposed to the matrix.**

Besides these spaces, there were also other types of spaces like offices or pubs to give some dynamic to the ambient. There is a total of 18 floors that were manually generated by this system but not all of them are accessible. The single purpose of these empty floors is to give a dynamic and "infinite" feeling to the outer ambient of the game [Figure 6]. Some of these floors are connected by stairs and, while the game takes place on a parallel universe where not everything has to make sense by the laws of physics, it still must be coherent and believable.

This coherence and believability in a place where the physics' laws may not apply as we know them are bound to the concept ambient that the authors wanted to give to the parallel universe.

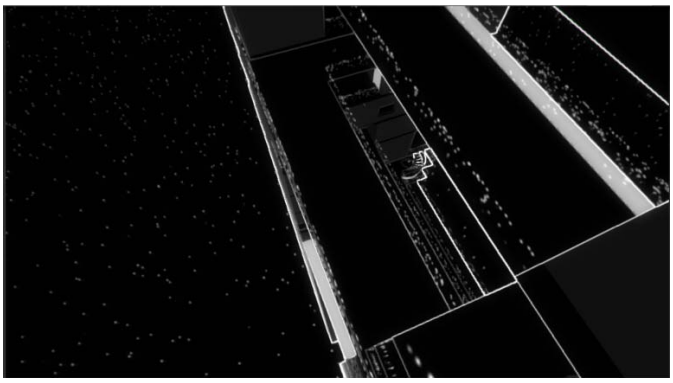

**Figure 6. Looking down to the Void.**

As depicted in Figure 7, this universe looks distant, silent, detached and freed from the physics' that we empirically know in our own world, but it still must look believable, to avoid losing the player's attention. To achieve this sense of detachment the game was emptied of colour information, keeping only the edges of the scene. The concept behind this is to reduce what the player needs to see to identify the fundamental shape of the space he's living in, based on his previous experience of the world, abstraction capacity and ability to identify the fundamental patterns that define something visually. However, there must be a balance between this ambient and how attractive it really is to the player so, to smooth the experience, two visual environments were developed, one that would emerge when the player is on the outside and another for the inside.

**Figure 7a. Exterior environment.**

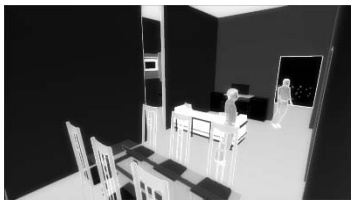

**Figure 7b. Interior environment.**

The outside environment has a stronger feeling of detachment [Figure 7a] by restricting itself only to a black and white visualization, while the inside environment had a wider range of greys [Figure 7b]. This could be achieved by means of the same image processing filters applied to both environments but with different parameterization. The pipeline is as follows [Figure 8]:

1. Sobel depth operator detected the edges on the scene based on its geometry [Figure 8b];
2. Then the colors were corrected with a filter that completely inverted the color scheme so the edges detected would be white, while the remaining elements were blacker [Figure 8c];
3. A bloom effect to exaggerate the whites and give a wider feeling of movement and dynamics [Figure 8d];
4. Tune the ambient light intensity;
5. Finally, antialiasing and motion blur effects were added to smooth the

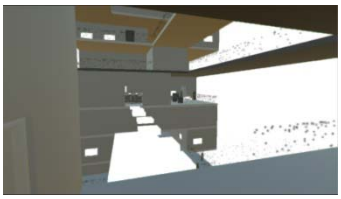

**Figure 8a. No effects.**

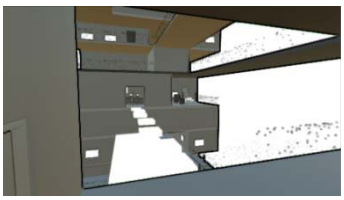

**Figure 8b. Sobel depth operator.**

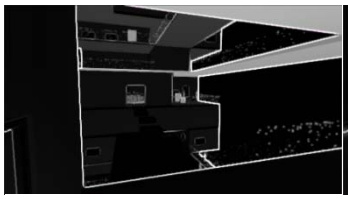

**Figure 8c. Color correction (invert).**

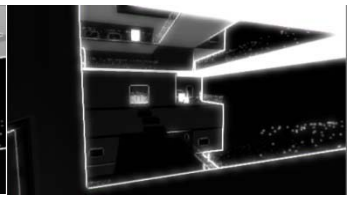

**Figure 8d. Bloom effect.**

visualization.

The scene had no lights so that the environment could be only controlled by the ambient lighting coupled with the image effects. The different visualizations were achieved by tuning the values of the ambient lighting intensity, changing the material of the floor, the bloom effect intensity, its threshold, and its blur spread.

The *Memory Mode* is conceptually connected to this environment because it represents a breaking out of that detached ambient, giving the player a glimpse of what is John's original universe. This also serves as a tool to guide the player through this strange graphical environment and to not overburden the player's abstract analysis capacity. The *Memory Mode* graphical effect is achieved by simply disabling the image effects previously described and tuning the ambient lighting to a comfortable value.

C. Artificial Intelligence and Interactive Storyline

Sarah, the daughter of the main character of the game John, is an intelligent agent. Throughout the game Sarah will help John solve the puzzles by giving him tips on how to proceed if he's stuck.

Sarah will help John according to his sanity level, speaking in a harsher way if John's sanity meter is higher than a given threshold. The tips also depend on the time John is taking to solve the puzzle, the longer he takes the more helpful the tips will be.

| | Low Insanity | High Insanity |
|---|---|---|
| First Help | Dad! I can reach you again…but in order to help you get out of here you'll have to come the north tower. There is a way to cross it! | Quickly! Time is running out, you have to cross the bridge to the north tower! |
| Final Help | In order to cross you'll have to be careful! There are moving platforms available between both towers that could serve as a bridge ☺ | We don't have much time left father! In order to cross try and use the moving platforms! |

**Figure 9. Example of the intelligent dialogs possible in the first puzzle, in which John must cross a bridge.**

To create this conversation system, the first thought was doing voice acting, however voice acting must be close to perfect to convey emotions to the player, or it doesn't work at all, also it would be too great of an investment and risk to do it. The final decision was to use subtitles for the dialogs, and in order to do this the authors created a subtitle system with good timings and identifications. This system has a built-in creation and editor (Unity's Editor) for conversations between two (or more) characters with parameters such as Author, Line and duration of that subtitle. Upon a "StartConversation (ID)" call from any script, it can start a conversation and the system will control the timing of each line delivery to our needs. Tests conducted showed that the first timings were too fast, so those values were doubled and now the cut-scenes with dialogs are easier to follow.

Parallel has an interactive storyline since all the actions the player takes when solving puzzle can directly affect how the story will end. Technically, the *Insanity* meter at the end of the game, which evolved throughout the game, will determine which plotline is used in the final act. Additionally, in the final act the player will have a decision to make, this decision will also change the outcome of the confrontation between John and his rival Richard.

D. Sound

After the development of every gameplay system and puzzles, the next step of development was adding an ambient sound to the game for it to produce an even better immersion in the player, and add action sounds for when certain actions were done such as picking up items.

Jukedeck [Jukedeck] allowed the generation of good sci-fi ambience music with a click of a button, and it was used to generate it. The game should not be fully mute, but the

ambience is very subtle and low volume to interfere little on the player's mood and performance.

## IV. Tests and Results

### A. Initial Tests

As mentioned previously the tutorial of the game was used to test the main functionalities of the game and check the acceptance of players to the environment and the graphics, as well as measure completion times of the tutorial.

Despite being informal tests, to contextualize the testers a test script was created and presented to each one before the test occurred. The script made it clear of the purpose for the testing, the element being evaluated was the game and not the subject's ability to play videogames. The script also introduced the subjects to the story.

The tests were conducted online via skype call or in person to 6 subjects. 5 subjects were male and 1 female, their ages between 20 and 25 years old. After being presented with the script, the testers accessed a website with the tutorial available to play.

For the environment acceptance test the results were very good, most subjects liked it and when asked about it mentioned they appreciated the obscure and dark feel of the environment. The graphics acceptance test revealed worse results, as pretty much all subjects identified them as being somewhat distorted or confusing. The interpretation made from these observations is that the motion blur used was too high and since the game was already dark it did not need this additional element that was causing confusion when playing. The decision of attenuating the motion blur effect was then taken by the developers.

Regarding observations on the mechanics of the game, all testers ended up choosing the sane way of solving the tutorial, which meant that there needed to be adjustments on the way the tutorial is presented, as it needs to be clear to the player he has both choices. In the middle of the tutorial there is a dialog scene between John and his daughter Sarah, however since the cut-scene didn't restrain the player to a certain area he could move around freely and it was noticeable that some testers didn't fully pay attention to the dialog between characters and were more interested in exploring the rest of the tutorial. This led to the decision of restraining the player whenever a cut-scene with dialog is taking place in the game.

Additionally, the data gathered from the tests showed some interesting results regarding completion times for certain sections of the tutorial. Even though players took some time to grasp the concept of *Memory Mode* in the beginning, even when explained as a subtitle, after successfully using it, they proved to be much more efficient when they needed to use it on the second and final event of the tutorial.

### B. Final Tests

After finishing the project and implementing over 60% of what was conceptualized in the beginning, new final testes were done. These tests were as formal as possible, however due to physical constraints they were all done via on-line and not in person.

For these final tests, a formal test script, test questionnaire and test observation sheet for the observers was create.

The questionnaire was made to classify each subject into a category and evaluate his experience and the game mechanics. The observer had an observation sheet available to measure some aspects of the test subject's gameplay, however since the tests were conducted online, these measures were applied automatically and captured through the game.

Along with these documents, a new build of the game was made just for these tests. The build is supposed to introduce the story of Parallel and give the users a first experience of the puzzles, and in that regard the build contains the tutorial and part of the 1st act that ends when the player reaches the end of the first puzzle.

The subjects were 5 males and 1 female with ages between 18 and 28 years old. The answers from the questionnaire revealed that the immersion created just from those two initial segments of the game are okay not excellent. On a scale of 1 to 5, the average of the 6 subjects was 3. The difficulty for the players to progress in the game is balanced, on a scale of 1 to 5, the subjects classified their difficulty with an average of 3.

The other three main components the authors wanted to test are:

- Graphical Environment
- Main player motivations
- *Memory Mode* mechanic

The graphical environment was reported as a bit confusing in the initial tests with the tutorial, so some adjustments were made. In the final tests however, there are still issues regarding the graphics. Around two thirds of the testers said they felt some sort of discomfort while playing, and justified mostly with the graphics twitching or lagging. In terms of the universe created, the subjects highlighted the map itself and it being "clean" looking.

Regarding the tester's main motivations to keep playing Parallel, the results from the questionnaire showed they mostly want to keep playing so they can explore the rest of the universe and one of the testers wanted to keep playing for the puzzles. The story of Parallel was not mentioned as a motivation to play and in a scale of 1 to 5, the average interest of the testers was 2 which is lower than ambitioned. One of the testers said he didn't understand the story at all and what was going on.

The *Memory Mode* mechanic was understood right from the beginning or through practice by the two thirds of the testers. Even though this is above average, it is still far from an excellent result because this is the most important mechanic in the game and the players should have it figured out by the end of the first puzzle, and one third of the testers did not. The average performance of the playthrough increased significantly in the puzzle compared to the tutorial (Figure 10), which is a relevant measure because the same pattern occurred in the initial tests.

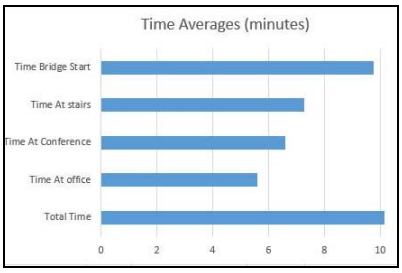


**Figure 10. Time needed to reach each stage of the game. The time is cumulative and not independent for each stage.**

Interestingly, in the final stage of the test, the bridge puzzle, most testers ended up choosing the insane route (manually jumping the platforms) instead of the sane way (using memory mode to pass the bridge), even though the insane route is much tougher.

## V. Conclusions and Future Work

The main focus in Parallel is a both enjoyable and immersive experience for casual to hardcore players, where they test their gaming skills and logical skills, while also being involved in a thrilling story of a struggling father and daughter in parallel worlds. We consider this game can provide those emotions and events to a player, so the primary objectives were fulfilled, however there are improvements to be made in order to enhance the player's experience as the tests revealed some subjects were not immersed at all in the game. Overall, considering the efforts put into the making of Parallel, the world models built from scratch, entire screenplay and script of the story, and implementation of new mechanics in Unity, the result obtained is very satisfactory for all the authors and we hope it can be recognized as a reference in the academic circle.

The future work for Parallel begins with the implementation of the second act of the story into the game engine. To improve the product, the authors also propose the addition of a main menu, for managing all the saved games and provide the ability to have different playthroughs at the same time, and the introduction of new artificial intelligence elements to the game, making it more dynamic with smart NPCs and obstacles.

There will also be a revision of the graphical environment since some play testers reported discomfort with the graphics used. The objective is to make them smoother, to prevent any form of twitching or bugging the player through walls from that same twitch.

The way the story is presented in the beginning of Parallel can be improved by gathering voice actors to play the characters, thus enhancing the involvement the player is having with the story.

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